

SIGS-S: A Set of Applications for Social and Health Care Data Management

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Abstract. *In Brazil, information systems have been used to support government activities, such as public social and health care. For instance, SIGS is a web information system to support management of government social programs. Another example of system is e-SUS, an information system to support health care data management. Considering that crossing data from social and health care may be helpful in decision-making for both areas, the SIGS-S project was proposed. It consists of a set of applications, based on e-SUS, composed by a web application for social and health data management, and a mobile application to support health data collection. Processes ProFap and ProFap-R were used during their development. As a result, the web application SIGS-S Web, the mobile application SIGS-S Mobile Saúde and web services to support cross-application data exchange were developed. Furthermore, it was prepared the documentation for both applications, aiming to help future software maintenance. Both applications were developed and validated with participation of stakeholders (health users and government managers).*

1. Introduction

In Brazil, information systems have been required by government institutions in order to support their work in different areas, such as management and monitoring of activities. An example of using information systems in this context is monitoring of social care benefits through web applications, such as the Information System on Social Management (Sistema de Informação em Gestão Social – SIGS) [Fernandes et al. 2014]. Other application of information systems is in the individual monitoring made by public health care system, such as the e-SUS – Primary Care ¹ [Brazil 2014]. e-SUS provides 7 health care forms to be used in different contexts, such as home care, odontologic care, and collective activities regarding health care promoted by the government. Moreover, mobile application have been proposed to support health care, such as GeoHealth [Pivetta 2010], UNA-SUS Dengue [UNA-SUS 2013], SAMU [Portal Brasil 2014], and e-SUS Home Care [Brazilian Health Ministry 2015].

The integration of systems from different areas of government action may be helpful for government entities, considering that crossing data can provide relevant information that can not be obtained by systems analysis individually. Accordingly, Leichsenring [Leichsenring 2004], based on his experience in systems development that integrate

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¹cited in this paper only by e-SUS.

social and health services, in Europe, for the benefit of elderly quality of life, states that it is hard to integrate social and health services because of economic, political and organizational factors for example.

Furthermore, Berg [2011] says the information system development and deployment in health care organizations is a process of mutual transformation (that is, transformation of the organization by the technology, and of the system by the organization). Thus, the deployment of an information system implies that it strategically will affect the organization. Because of this, the author highlights the importance of the participation of different users during the health care information system development.

From this perspective and given the absence of software solutions of the Brazilian government that integrate social and health areas because of the Health in The Family Program (Programa Saúde na Família), this work presents the Information System on Social and Health Management (Sistema de Informação em Gestão Social e da Saúde – SIGS-S), a set of applications for social and health integrated data management. The development of this system is supported by software processes concerned with the involvement of users.

SIGS-S was developed in a research project [Cagnin et al. 2012] of the Laboratory of Software Engineering (Laboratório de Engenharia de Software – LEDES) at the Federal University of Mato Grosso do Sul (UFMS). This project is composed by the web application SIGS-S Web and the mobile application SIGS-S Mobile Saúde. The web application was designed to provide the registration of social data (through the subsystem SIGS-S Web Social) and the registration of health data from families (through the subsystem SIGS-S Web Saúde). Furthermore, the web application provides management reports to assist in social and health-related decision making. In turn, the mobile application was designed to support the collection of health data to be sent to SIGS-S Web Saúde. The web application was developed in PHP 5.4 with support of Titan Framework [Carromeu et al. 2010], and the mobile application was developed for Android platform in Java with support of technologies such as SQLite², JSON³, and OrmLite⁴.

Processes ProFap [Cagnin et al. 2013] and ProFap-R [Fernandes et al. 2014] were used in the development of the SIGS-S applications. The first was applied in the development of SIGS-S Web Saúde and SIGS-S Mobile Saúde. The other was applied in the development of SIGS-S Web Social because it is a result of reengineering of the legacy system SIGS, previously mentioned. As a result, we developed the cited web and mobile applications, in addition to the web services to support data exchange between SIGS-S Web Saúde and SIGS-S Mobile Saúde. The developed applications were validated by health users and Brazilian government managers.

The remainder of this paper is organized as follows. Section 2 presents a background to support the comprehension of our study. Section 3 discusses the overall design of the SIGS-S applications. Section 4 details the construction of SIGS-S Web, a web application to support both social and health care data management. Section 5 describes the construction of SIGS-S Mobile Saúde, a mobile application integrated with the health

²<https://www.sqlite.org/>

³<http://www.json.org/>

⁴<http://ormlite.com/>

care module of the web application. Section 6 discusses the evaluation of web and mobile application, and also presents some limitations of both applications. Section 7 presents related work. Finally, Section 8 concludes this paper with a discussion and suggestions for future work.

2. Background

This section presents two different software processes used to develop the applications that compose SIGS-S. Section 2.1 presents ProFap, a process to support developers of software and used in the development of SIGS-S Mobile Saúde. Section 2.2 presents ProFap-R, a process to support reengineering of software systems used during the development of SIGS-S Web Social.

2.1. ProFap

ProFap [Cagnin et al. 2013] is a collaborative software maintenance process integrated with some support tools. Currently, it is used in several LEDES projects, not only in software maintenance, but also in software development. It was also used in the development of SIGS-S Web Saúde and SIGS-S Mobile Saúde. ProFap consists of six stages whose flow is illustrated in Figure 1. A brief description of each step is done below:

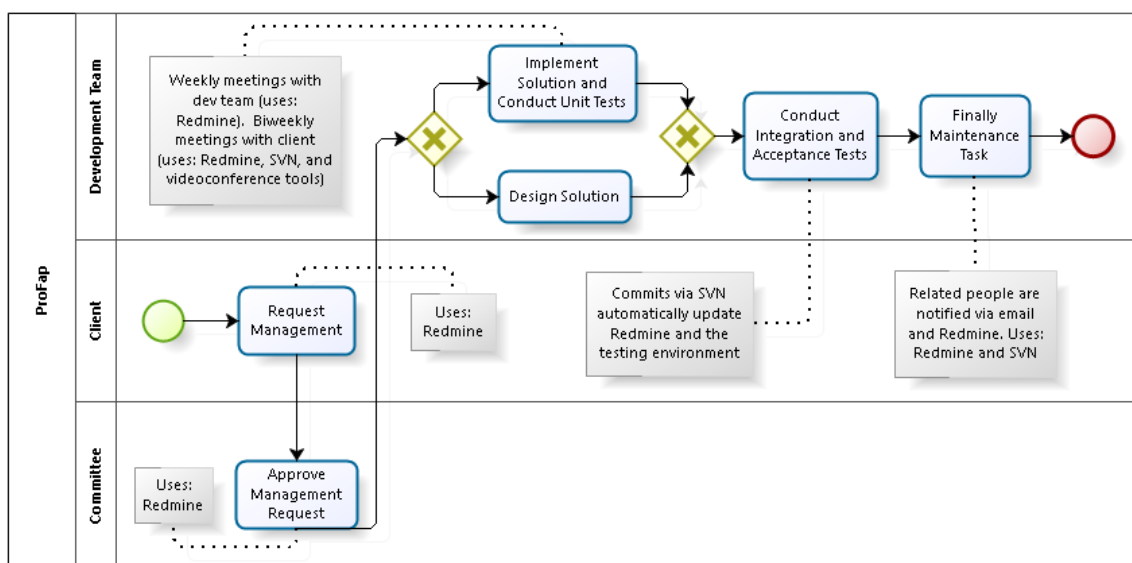


Figure 1. Stages of ProFap [Fernandes et al. 2014].

- *Request Maintenance*: this is the stage where the request of maintenance is made, via Redmine. Its is also where the bugs of the system are reported. If the request is related to a corrective maintenance, then the request is assigned to a developer. Otherwise, if the request is related to the development of a new module or functionality, then it is analyzed by committee representing different types of stakeholders,
- *Approve Maintenance Request*: this is the stage where a request is evaluated. Here, a request can be approved or discarded,
- *Design Solution*: after approval of a request, it is assigned to a developer. Developers with related tasks can discuss different ways of designing a solution for their tasks, together with the team leaders,

- *Implement Solution and Conduct Unit Tests*: this is the stage where the designed solution is implemented, using the SVN versioning. This is where the functional and unit tests are conducted by the developer in local environment. This stage occurs in parallel with the stage Design Solution,
- *Conduct Integration and Acceptance Tests*: this is the stage where the test environment is updated, via SVN integrated with Redmine, with the implementation result. Then, integration tests are conducted in test environment. The developer may request support from other development teams during the acceptance tests that are always done by the client, and
- *Finally Maintenance Task*: this is the stage where the request is closed, via Redmine, and the production environment is updated using SVN.

As previously mentioned, among the tools to support ProFap, the following are recommended: the system for project management and reporting bugs Redmine⁵; and the software versioning and revision control system Subversion (SVN)⁶.

2.2. ProFap-R

Software reengineering is the process of analyzing software system artifacts to support the development of a new system based on the existing implementation [Chikofsky and Cross 1990]. In this context, ProFap-R [Fernandes et al. 2014] is an adapted version of ProFap to support code reengineering oriented by data reengineering. This because, according to Pérez-Castillo et al. [2013], existing databases should not be discarded during the software modernization as they contain valuable business knowledge not present elsewhere. The same tools used in ProFap may be used in ProFap-R. ProFap-R consists of nine stages whose flow is illustrated in Figure 2 and described below:

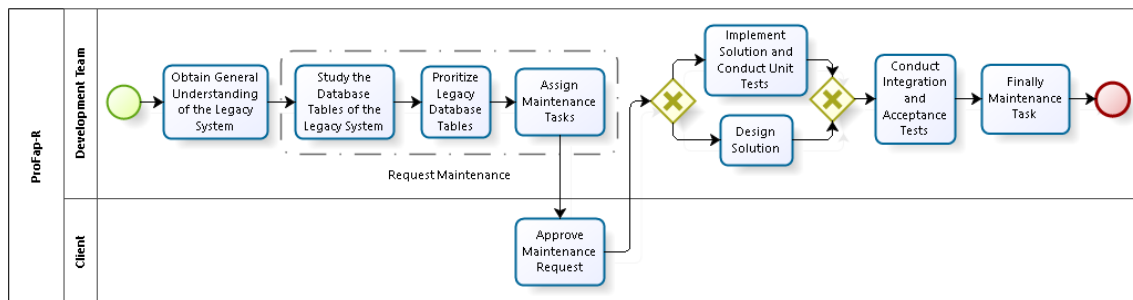


Figure 2. Etapas do ProFap-R [Fernandes et al. 2014].

- *Obtain General Understanding of the Legacy System*: this is the stage where is conducted a general study about the legacy system domain that will be submitted to reengineering. This is also the stage where the technology to be used in the implementation is defined,
- *Study the Database Tables of the Legacy System*: this is the stage where the development team understands the legacy system and documents its tables,
- *Prioritize Legacy Database Tables*: this is the stage where the tables are prioritized according to their dependencies. This prioritization will determine the order of submission of the tables to reengineering,

⁵<http://www.redmine.org/>

⁶<https://subversion.apache.org/>

- *Assign Maintenance Tasks*: this is the stage where the maintenance tasks are assigned to the developers according to the prioritization done. The understanding of each functionality of the legacy system and the business rules associated are based on the execution of the legacy system,
- *Approve Maintenance Request*: this is the stage where is conducted the client review about the features submitted to reengineering. If the client is not available to evaluate the features, then this stage is omitted,
- *Design Solution*: this is where the legacy tables related to the request are evaluated in order to define the tables that will be implemented, and
- *Implement Solution and Conduct Unit Tests*: this is the stage where the tables related to the request are passed to the new database. The scripts of the legacy database can be reused or discarded. The functionality related with the tables of request is implemented using the technologies defined in first stage.

The other two stages, “Conduct Integration and Acceptance Tests” and “Finally Maintenance Task”, are similar to the ProFap stages (see Section 2.1).

3. Design of SIGS-S

The Information System on Social and Health Management (Sistema de Informação em Gestão Social e da Saúde – SIGS-S) is a project developed by a team that consists of ten undergraduate students in Computer Science and Systems Analysis, six teachers from UFMS, and two professionals from the Single Health System of Mato Grosso do Sul (Sistema Único de Saúde do Estado de Mato Grosso do Sul – SUS-MS). SIGS-S consists of the following applications:

- *SIGS-S Web*: this is a web application for social and health data record. It consists of two subsystems: SIGS-S Web Social (for social data) e SIGS-S Web Saúde (for health data) [Ortiz et al. 2014]. Both subsystems are accessed through a single user interface, according to the user’s access privileges; and all data are stored in a single database, and
- *SIGS-S Mobile Saúde*: this is a mobile application to support health data collection. The collected data is sent to SIGS-S Web Saúde using web services [Fernandes et al. 2015].

The project was completed in December 2014 and sent, in the first half of 2015, to the Information Technology sector of the Health Department of Mato Grosso do Sul to be analyzed and maybe deployed in the context of health care of SUS-MS. Section 4 provides a detailed discussion regarding the construction of SIGS-S Web, and Section 5 presents the construction of SIGS-S Mobile Saúde.

4. Construction of SIGS-S Web

This section presents details of the construction of SIGS-S Web. Section 4.1 describes the web application in terms of goals, features, technologies used to develop the application, and other relevant information. Sections 4.2 and 4.3 provide details with respect to SIGS-S Web Social and SIGS-S Web Saúde, respectively. Section 4.4 presents the overall user interface of SIGS-S Web.

4.1. Design of SIGS-S Web

The main goal of the integration between social and health systems is to provide management reports with data crossing between subsystems [Ortiz et al. 2014]. Therefore, SIGS-S Web was implemented in modules, where each module has an specific feature of the system, and each module can have exclusive access or be shared between subsystems. The modules that are shared and accessible to both social and health subsystems are:

- *Access Control*: designed for management of SIGS-S Web social and health users,
- *General Data*: for metadata management. Metadata were conceived to support users through filling out social and health forms,
- *General Reports*: for generation of reports with data crossed from social and health sub-applications, and
- *Help*: designed to support the system users.

The technologies that were selected to develop SIGS-S Web are listed in Table 1. SIGS-S Web was developed with support of Titan Framework. This is a framework developed in PHP and XML that belongs to the e-government domain [Carromeu et al. 2010]. Titan uses the Model-View-Controller (MVC) pattern [Fowler 2002].

Purpose	Tool
BPMN Diagrams	Bizagi Modeler
Logical Models	brModelo
Framework for Web Development	Titan Framework
Graphic User Interface for Database Management Systems	pgAdminIII
Markup Language	XML 2.0
Markup Language for Web Pages	HTML 5.0
Programming Language	PHP 5.4
Dynamic Programming Language	JavaScript
HTTP Server	Apache 2
Database Management Systems	PostgreSQL 9.1

Table 1. Technologies used to develop SIGS-S Web [Ortiz et al. 2014].

Basically, Titan receives as input configuration files (written in XML and SQL) from the application instance. Then, the framework configures the business rules of new application editing the XML file and, if it is not enough, it is possible to program new software components that can be available in the Titan repository according to its generalization. The use of Titan Framework provided a lot of advantages to the SIGS-S project, such as more control about user access permissions, organization of the project in MVC layers and sufficient usability of the user interface.

The development of SIGS-S Web followed the MVC architecture adopted by Titan. In Figure 3 it is illustrated the SIGS-S Web architecture. All the features of Titan are organized in a model based on sections and actions. A section represents a feature of the application, such as a home visit form (in the package `health.homeVisit`). Actions are operations that users can do in a feature, such as create, edit and visualize data. Each action of a feature is kept in the directory that represents the feature section (for example, the actions of creation, edition and listing of the package `health.homeVisit`). Each section is located into the package `SIGS-S Web`. This package represents the instance of the system. The package `Titan` represents the core of the framework.

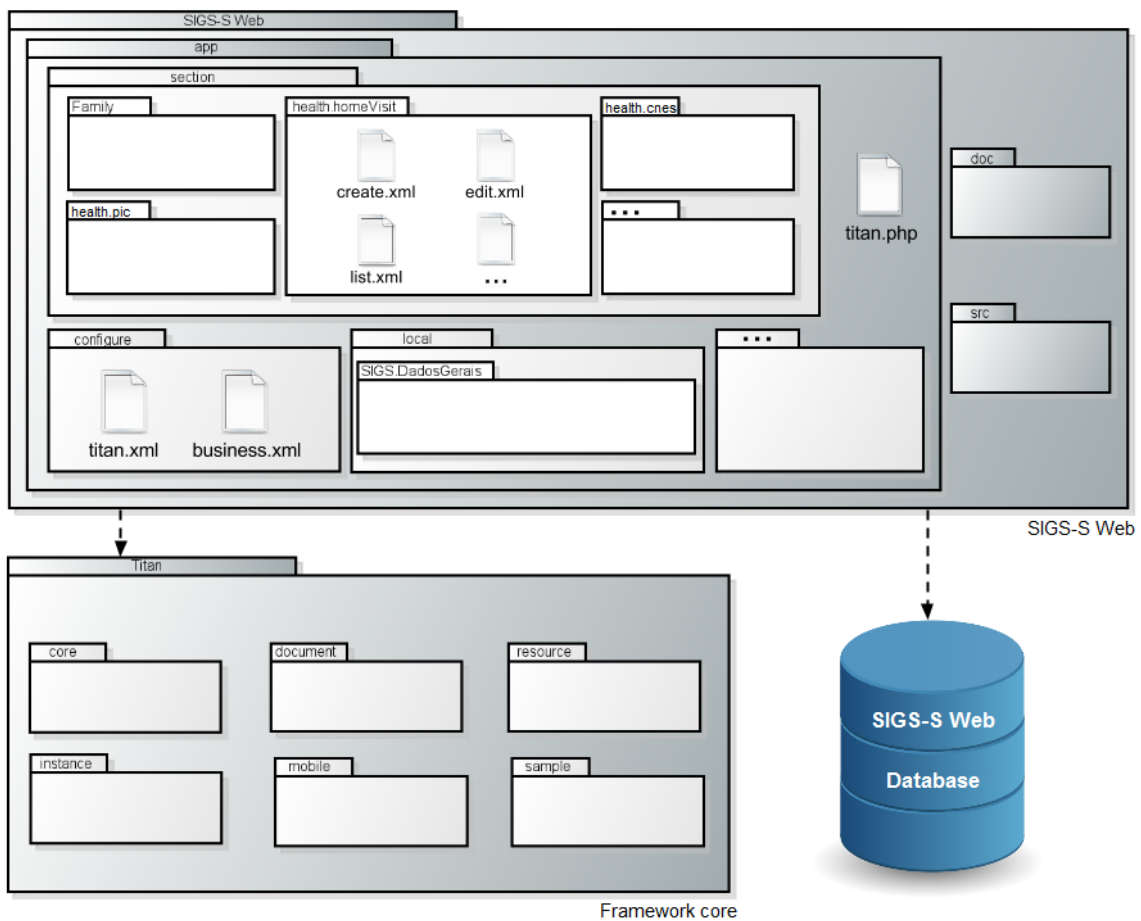


Figure 3. Architecture of SIGS-S Web [Ortiz et al. 2014].

4.2. SIGS-S Web Social

SIGS, a legacy system used as basis for the development of SIGS-S Web Social, consists of various modules, each one with its own features. The SIGS-S Web Social development team, together with stakeholders, selected the modules that would be sent to reengineering. Thus, the modules submitted to reengineering process are:

- *General Data*: for metadata management. Metadata is used for filling forms,
- *Institution*: for institution data management,
- *Family*: for management of families that are served by social programs,
- *Reports*: for generation of management reports,
- *Technical Team*: for management of social users, and
- *Territory*: for territorial schema management.

With respect to the other modules from the legacy system, they were considered by stakeholders as outdated or out-of-context in the current social assistance settings. Therefore, the following 4 modules were not sent to reengineering:

- *Academic Grant*: in the legacy system, it was used to support the management of the Academic Grant social program. It was not considered in the reengineering because some institutions do not need this feature anymore,

- *Administrative Management*: in the legacy system, it was used for managements of grant payments. It was discarded because payment was not covered by the project purposes,
- *Graphs*: in the legacy system, it was used for generating management reports, presenting data in graphs. It was discarded because was not fully implemented in the legacy system and we have no access to documentation about the module, and
- *Socioeducational Groups*: in the legacy system, it was used for reunion managements among social professionals and served families. It was discarded because it is no longer necessary.

The development of SIGS-S Web Social was supported by ProFap-R (see Section 2.2). The understanding of the legacy system was built based on the execution of SIGS. The development was also based on the legacy database scripts because we have no access to documentation about the legacy system and it was difficult to understand the legacy source code.

Use of ProFap-R in the Development of SIGS-S Web Social.

SIGS-S Web Social is the result of the reengineering of the legacy web application SIGS. During the design of the new application, it was necessary to adopt a software process to support code reengineering oriented by data reengineering, considering that the most usable part of the legacy system was the database. Thus, it was proposed the process called ProFap-R [Fernandes et al. 2014], to be first used to support the SIGS reengineering.

Then, ProFap-R was used during the development of SIGS-S Web Social, including in respect of meetings with the stakeholders (users and government managers) and the use of support tools. The allocation of tasks to developers and the documentation of each task were made via Redmine in the stage “Request Maintenance”, after the stage “Obtain General Understanding of the Legacy System”. The allocation was defined during the weekly meetings. The meetings were documented via Redmine.

After the task allocation, it was conducted the approval of tasks by the stakeholders in the stage “Approve Maintenance Request”. In this task, some features of the legacy system were discarded because of lack of need. In the stage “Design Solution”, solutions for the assigned tasks were designed based on its description and in the Titan Framework features. In “Implement Solution and Conduct Unit Tests” occurred the creation of database scripts related to the tasks and the development of functionalities related to created tables. In addition, unit tests were conducted.

In the stage “Conduct Integration and Acceptance Tests” were conducted integration tests by the development team and acceptance tests together with the stakeholders. In the latter, meetings were conducted to present and validate the results with the stakeholders. After the conclusion of each task, the production environment was updated with the new implementations in the stage “Finally Maintenance Task”. The graphical user interface of SIGS-S Web Social is illustrated in Figure 4.

4.3. SIGS-S Web Saúde

The main purpose of SIGS-S Web Saúde is, based on e-SUS, provide the filling of health forms used by the health primary care provided by SUS-MS. Furthermore, as an advan-

Figure 4. User interface of SIGS-S Web Social (in this case, the interface of the Register Family form).

tage when compared to e-SUS, SIGS-S Web Saúde provides integration with a mobile application for health data collection called SIGS-S Mobile Saúde. The specific modules of SIGS-S Web Saúde are:

- *General Health Data*: for metadata management. Metadata is used for completing health forms,
- *Health Forms*: for filling of health forms. This module was created based on forms provided by e-SUS,
- *Request Mobile Import*: this module was conceived to provide a preparation of data to be imported by a device with SIGS-S Mobile Saúde installed,
- *Mobile Device Management*: for mobile devices management in order to ensure the use of the mobile application by authorized mobile devices only, and
- *Health Reports*: for generation of management reports using health data only.

Use of ProFap in the Development of SIGS-S Web Saúde.

After the reengineering of SIGS resulting in SIGS-S Web Social, the next step was the development of SIGS-S Web Saúde supported by ProFap. In the stage “Request Maintenance”, meetings were conducted with the stakeholders to know the necessary features to the system. In the stage “Approve Maintenance Request” the development team made weekly meetings to discuss the viability of each system feature proposed in the previous stage.

In the stage “Design Solution”, it was discussed ways of implementation for each development task. The design decisions were documented in the technical manual of the application. In parallel, in the stage “Implement Solution and Conduct Unit Tests”, the development team implemented the source code and conducted unit tests.

In the stage “Conduct Integration and Acceptance Tests” the integration tests were conducted by the development team and the acceptance tests were made together with the stakeholders. In the latter, meetings were conducted to present and validate the results with the stakeholders. At last, in the stage “Finally Maintenance Task”, the source code was versioned using SVN repository. The graphical user interface of SIGS-S Web Saúde is illustrated in Figure 5.

Figure 5. User interface of SIGS-S Web Saúde (in this case, the interface of the Individual Registration form).

4.4. User Interface of SIGS-S Web

Figure 6 illustrates the overall user interface of SIGS-S Web. Considering that SIGS-S Web gather two subsystems (namely, SIGS-S Web Social and SIGS-S Web Saúde), we decided to implement a common initial interface for user authentication. Figure 6(a) presents the welcome screen for user authentication, by requiring username and password. Figure 6(b) shows the main screen of the SIGS-S Web application, common to both social and health users. Figure 6(c) presents the main menu of SIGS-S Web, to provide for users the common features between Social and Health subsystems, and also for users to choose which subsystem to access. Note that the availability of subsystem access depends on the type of user (for instance, the health secretary is allowed to access features from both social and health areas).

5. Construction of SIGS-S Mobile Saúde

This section presents details of the construction of SIGS-S Mobile Saúde. Section 5.1 describes the overall design of SIGS-S Mobile Saúde in terms of purpose, main features, and other relevant information. Section 5.2 presents the development technologies used to implement the mobile application. Section 5.3 presents the architecture of SIGS-S Mobile Saúde. Section 5.4 discusses the use of ProFap during the mobile application development. Finally, Section 5.5 presents the user interface of the application.

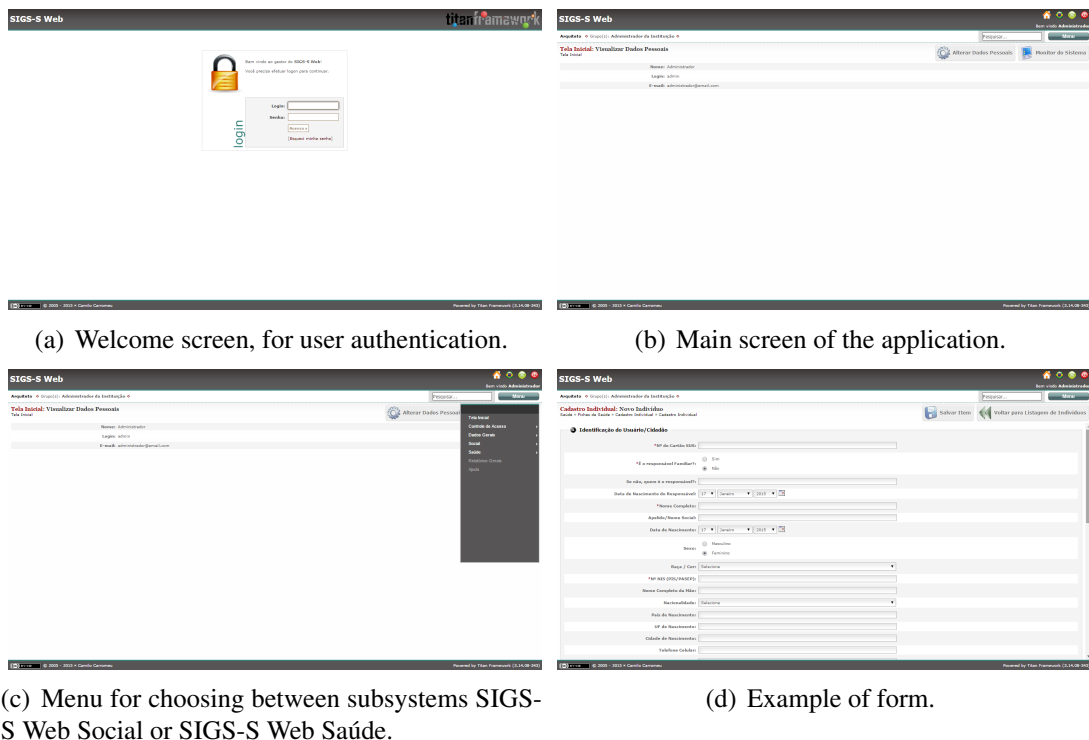


Figure 6. User interface of SIGS-S Web.

5.1. Design of SIGS-S Mobile Saúde

SIGS-S Mobile Saúde [Fernandes et al. 2015] was conceived to support health data collection to be sent to SIGS-S Web Saúde. The idea is to provide a way of health professionals to fill forms remotely, in places where there is no internet connection, through mobile devices. Then, the collected data is exported to SIGS-S Web database via internet.

SIGS-S Mobile Saúde was conceived to provide: metadata and professional data for completing forms, health forms inspired in the forms provided in SIGS-S Web Saúde and data export to SIGS-S Web [Fernandes et al. 2015]. Figure 7 illustrates an example of usage for SIGS-S Mobile Saúde. Each step is described as follows [Fernandes et al. 2015]:

1. The user, in possession of a mobile device, registers the device in SIGS-S Web Saúde for future installation of the mobile application,
2. Then, the user installs SIGS-S Mobile Saúde and Barcode Scanner on the registered mobile device,
3. Then, the user performs the first access to SIGS-S Mobile Saúde. Thus, the mobile application is automatically redirected to Barcode Scanner for device registration using QR code. From there, the mobile device is associated to SIGS-S Web Saúde and authorized to use the mobile application,
4. Then the user performs an authentication in the mobile application. The user must be user of the web application to be able to authenticate,
5. If authentication is successful, then the user can access the application features. But, before the form filling starts, it is necessary that the user performs metadata and professional data import,

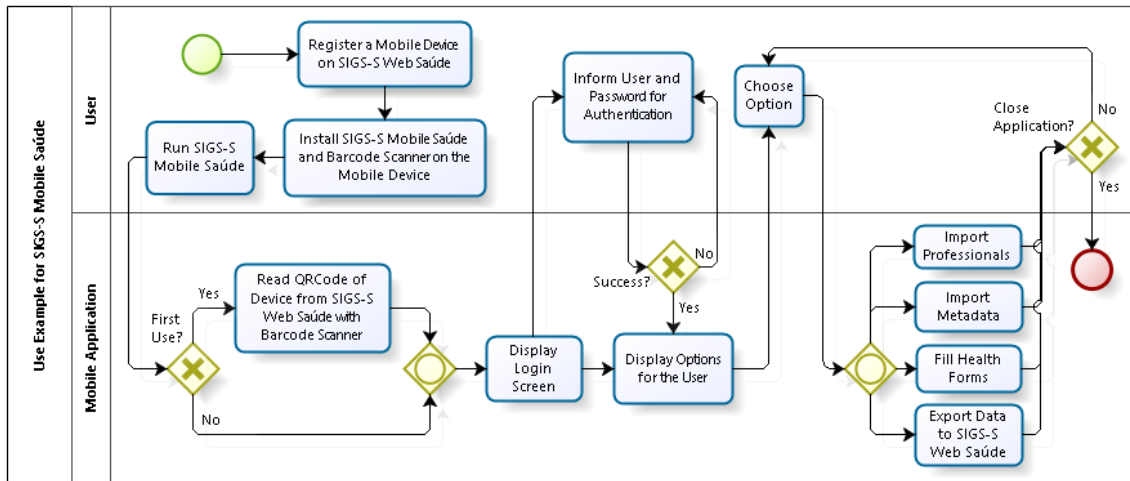


Figure 7. Example of use for SIGS-S Mobile Saúde.

6. The user can, in this stage, fill health forms, and
7. When the form filling is finished, the user exports the collected data to SIGS-S Web via internet. Thus, the exported data is deleted from the mobile device.

5.2. Adopted Technologies

The technologies chosen to develop SIGS-S Mobile Saúde are listed in Table 2. They include SQLite for data management, JSON protocol for data exchange, and OrmLite for data persistence. The minimum requirements to use SIGS-S Mobile Saúde in mobile devices, aiming to avoid problem of execution and slowness, were defined as follows [Fernandes et al. 2015]: display size greater than or equal to seven inches, Google Android⁷ operating system in the version 3.0 or greater, 500 MB storage, 1 GB RAM, wireless connectivity and GPS.

Purpose	Tool
Software Library for Mobile Databases	SQLite
Mockup Tool	Fluid UI
Standard Format for Data Transmission	JSON
Integrated Development Environment for Android Development	Eclipse ADT
Application Programming Interface for Android Platform	Levels 14 to 19
Graphic User Interface for Database Management Systems	pgAdminIII
Markup Language	XML 2.0
Programming Language for Android Applications	Java
Package for Object-Relational Mapping and Data Persistence	OrmLite
Graphical Client for Subversion	SVN Workbench
Programming Language for Web Service Implementation	PHP 5.4

Table 2. Technologies used to develop SIGS-S Mobile Saúde [Fernandes et al. 2015].

⁷<https://www.android.com/>

5.3. Architecture of SIGS-S Mobile Saúde

The architecture of SIGS-S Mobile Saúde is illustrated in Figure 8 and was based on Android application patterns. Basically, the architecture of the mobile application consists of the following layers:

- *User interface layer*: it is responsible for user interaction with the application,
- *Controller layer*: it is responsible for interface control as the user interacts with the application,
- *Business layer*: it consists of the entities that can be persisted on the database,
- *Persistence layer*: it is responsible for the database persistence. It is used the OrmLite package to support data persistence, and
- *Infrastructure layer*: it consists of the web service scripts that provide communication between SIGS-S Web and SIGS-S Mobile Saúde. It consists also of the mobile database.

5.4. Use of ProFap in the Development of SIGS-S Mobile Saúde

The development of SIGS-S Mobile Saúde was supported by ProFap [Fernandes et al. 2015]. In the stage “Request Maintenance” it was conducted meetings among stakeholders and development team to discuss needs of the application to be developed. The meetings were made via email or in person.

In the stage “Approve Maintenance Request” the weekly meetings were made by the development team to discuss the viability of the application features proposed in the previous stage. In the stage “Design Solution” it was discussed the best ways to implement each assigned task. The design decisions were documented in the technical manual of the application. In parallel, in the stage “Implement Solution and Conduct Unit Tests” the development team implemented the source code and conducted unit tests.

To guide us in the development of SIGS-S Mobile Saúde, based on the ProFap process, we defined the following steps:

- *User interface implementation*: this step consisted of the user interface implementation aiming to design the visual layer of the application. The arrangement of items on the forms follow the original arrangement of the e-SUS forms,
- *Database implementation*: this step consisted of the database implementation (database classes and data persistence). The tables were prioritized as follows: first the metadata tables, after the other tables,
- *Data import implementation*: this step consisted of the implementation of data import scripts (to transfer data from SIGS-S Web to SIGS-S Mobile Saúde). Furthermore, it was implemented features to support data import in the mobile application,
- *Professional data import implementation*: this step consisted of the professional data import feature implementation, as well as other features to support the data import, and
- *Export data implementation*: this step consisted of the export feature implementation, in addition to web services to provide the exportation from SIGS-S Mobile Saúde to SIGS-S Web.

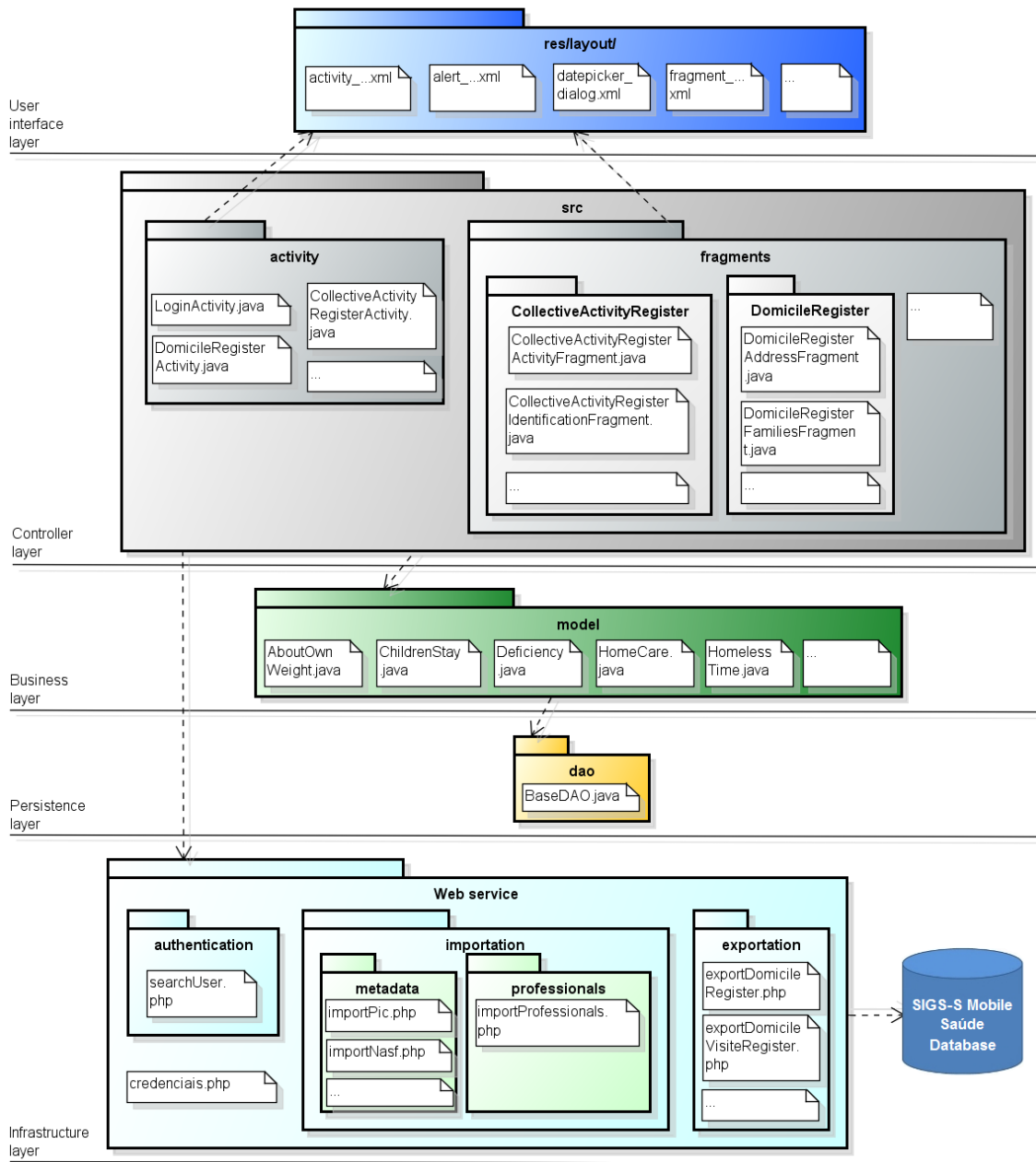


Figure 8. Architecture of SIGS-S Mobile Saúde [Fernandes et al. 2015].

In the stage “Conduct Integration and Acceptance Tests” were conducted integration tests by the development team and acceptance tests together with the stakeholders. In the latter, meetings were conducted to present and validate the results with the stakeholders. Finally, in the stage “Finally Maintenance Task”, it was made the source code versioning using SVN.

5.5. User Interface of SIGS-S Mobile Saúde

The user interface of SIGS-S Mobile Saúde was designed to be similar to the interface of SIGS-S Web Saúde, in order to help the user in adapting to the use of the mobile application. Furthermore, it was developed following the visual patterns of the forms available by e-SUS, to make easier the usage learning of the application.

Figure 9 illustrates part of the SIGS-S Mobile Saúde usage. Figure 9(a) represents the welcome screen of the mobile application. This screen requires username and password to provide user authentication. Figure 9(b) presents a form screen with focus on the field validation we implemented. This validation is required because some fields of forms are mandatory and can not be empty. In this example, fields with red markers are mandatory. Figure 9(c) presents another form screen. In the right superior part of this figure, we have a navigation menu. Finally, Figure 9(d) illustrates a verification for completing and recording form, so users may discard all changes or to record the filled form before leaving the form screen.

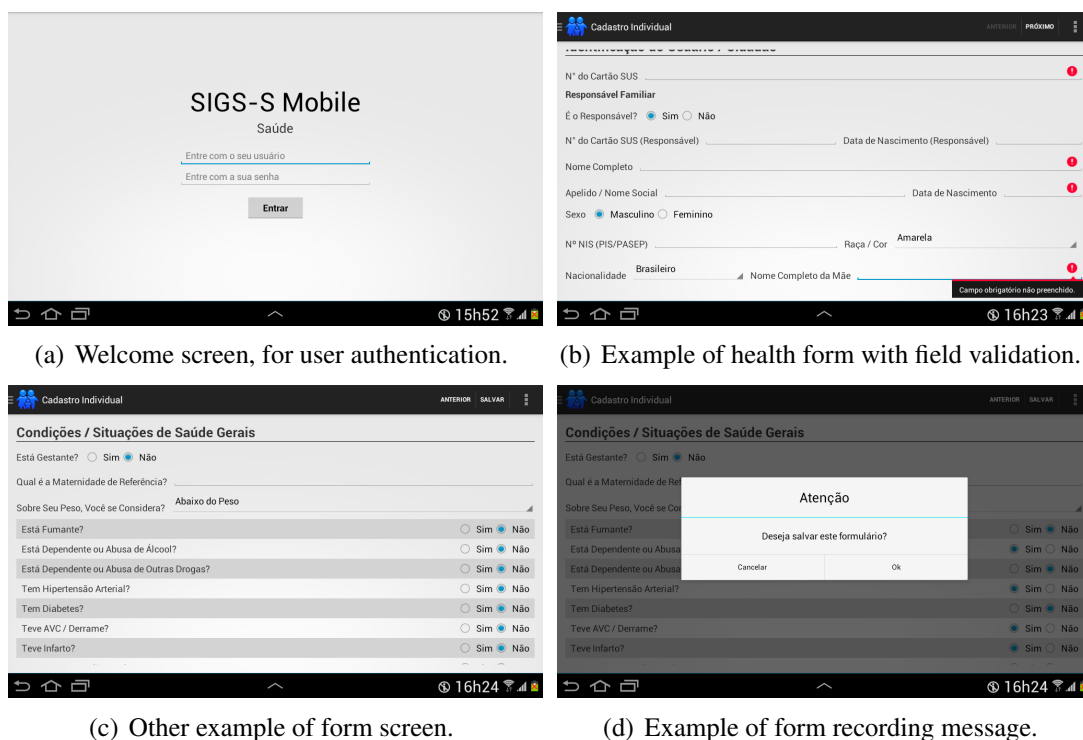


Figure 9. User interface of SIGS-S Mobile Saúde.

6. Evaluation and Limitations

In this paper, we present two applications that composes the SIGS-S project: (i) SIGS-S Web, to support social and health care data management, and (ii) SIGS-S Mobile Saúde,

a mobile application to support health care data management only. To assure that our proposed applications fits to the stakeholders' needs, we conducted an evaluation of both applications during their development.

During the reengineering of SIGS, we provided releases of SIGS-S Web Social in an approval environment, hosted in one of the servers from Software Engineering Laboratory (Laboratório de Engenharia de Software – LEDES). The same practice was adopted during the development of SIGS-S Web Saúde. After each release of SIGS-S, the participants of our project conducted functional testing aiming to assess whether the form data of SIGS and e-SUS, under development in this iteration, were available in the last release and appropriately available in the graphical user interface of SIGS-Web. Moreover, in the weekly meetings, the development team of SIGS-S Mobile Saúde had to present the last application release to receive feedback from the other project participants, with respect to design-related decision-making, user interface design, and other relevant issues.

Every three months, the development team used to meet with health care professionals from the Estate Health Department (Secretaria de Saúde do Estado) to present the most recent release of both SIG-S Web and SIGS-S Mobile. For instance, one of the main suggestions provided by health care professionals to improve our applications was with respect to the user interface of SIGS-S Mobile Saúde, it was necessary to provide the same presentation order of graphical resources when compared with SIGS-S Web Saúde. This suggestion was provided to ease the learning process of the use of both applications and, consequently, to improve the usability of the applications.

Therefore, considering the previously discussed evaluation strategies, we may assume that the development of both applications, SIGS-S Web and SIGS-S Mobile Saúde were guided by continuous assessment of functional, operational, and interactive (in terms of user interface) aspects.

Finally, our study has some limitations. First, regarding SIGS-S Web: (i) the use of Titan Framework to support the application implied some constraints mainly with respect to the integration between web and mobile applications, and (ii) we may have not implemented all features from SIGS legacy system because of limitations in the reengineering process. Second, with respect to SIGS-S Mobile Saúde: (i) we did not conduct the implementation of all the features from SIGS-S Web, such as user management, (ii) it was not developed a mobile application to support social care data management, and (iii) it was not considered, in both applications, other usage scenarios than the most common, as described in Section 5.1.

7. Related Work

This section provides a discussion with respect to related work, considering the two applications (web and mobile) we present in this paper. Section 7.1 presents some information systems designed to support government activities such as social and health care management. Section 7.2 shows some mobile applications that aim to support health care.

7.1. Related Information Systems

SIGS is a web information system with 498,769 source code lines and 383 tables, developed in 2000 by the Institute of Special Studies (Instituto de Estudos Especiais – IEE) of the Pontifical Catholic University of São Paulo (PUC-SP). Its purpose is to register social

data for monitoring social programs of the Brazilian government. It is a legacy system because the ASP technology and the database management system SQL Server 2000, used to develop SIGS, are obsolete and the system source code has poor quality (replicated and unused code, lack of standardization, deteriorated design, etc.) [Fernandes et al. 2014].

SIGS offers registration of social programs, as well as individuals and families served by these programs. Furthermore, the system provides management reports to help decision making of the Brazilian government. The use of SIGS can be summarized as follows: social professionals collect data from people; then, the collected data is registered in the system by the technical team; finally, it is possible to generate management reports. Because of its relevance in the context of the Brazilian government social care, and considering that SIGS is a legacy system, Cagnin et al. [2012] decided to submit SIGS to reengineering, resulting in a new system called SIGS-S Web Social as shown in Section 4.2.

Regarding current information systems for health primary care of the Brazilian government, there is the **e-SUS** [Brazil 2014], an information system for data health register regarding the National Plan for Primary Care (Plano Nacional de Atenção Básica – PNAB) [Brazilian Health Ministry 2012]. This application provides services such as the filling of entries and records used by health primary care. The entries available in e-SUS are: Household Registration and Individual Registration. The forms are: Individual Care, Odontologic Individual Care, Collective Activity, Procedures and Home Visit.

After the reengineering of SIGS, SIGS-S Web Saúde and SIGS-S Mobile Saúde were developed and based on the entries and forms from e-SUS. The result is a single platform with social and health data from families belonging to the Health Care Program of the Brazilian government, as described in Section 3.

7.2. Mobile Applications for Health Care Support

Many mobile applications have been proposed to support health care. For instance, Geo-Health [Pivetta 2010] is a mobile application to support data collection to the primary health care. It was developed by the West Region Project (Projeto Região Oeste) of the School of Medicine of the University of São Paulo (FMUSP). The data collected by this application is sent to the Information System of Primary Care (Sistema de Informação da Atenção Básica – SIAB), that is a system being replaced by e-SUS.

UNA-SUS Dengue [UNA-SUS 2013], released in December 2012 by the Open University of SUS (Universidade Aberta do SUS – UNA-SUS), was designed to aid in the diagnosis and treatment of dengue. Another application is called e-SUS SAMU [Portal Brasil 2014], released in January 2014 by the Ministry of Health. It was developed to support service requests for the Emergency Mobile Service (Serviço de Atendimento Móvel de Urgência – SAMU) via mobile devices.

e-SUS Home Care (e-SUS Atenção Domiciliar – e-SUS AD) [Brazilian Health Ministry 2015] was designed specifically for home care data collection. It provides registration of citizen and health care records. This application is integrated to a desktop application called Citizen Electronic Medical Record (Prontuário Eletrônico do Cidadão (PEC) for data exchange. Finally, AtendSaúde [Novetech 2015] was developed by Novetech in 2014 and implanted in a city of State of Bahia in 2015.

It was designed to support processes automation in both private and public health care context. In the public context, it supports regulatory processes and pharmaceutical care.

Although there are many proposals of web and mobile applications to support health care, none of them provides a web platform for health care management integrated with a mobile application to support on-site health data collection performed by health user workers.

8. Conclusion

The main contributions of this work are: the reengineering of a legacy social information system (that is, SIGS) that is relevant for social health; the development of a web information system that joins social and health data (SIGS-S Web); and the development of a mobile application to support the web application (SIGS-S Mobile Saúde) providing remote data collection in places where there is no internet connection.

Stakeholders (health users and Brazilian government managers) participated during development and validation of both web and mobile applications. This has been facilitated by the software processes ProFap and ProFap-R, which encourages the user participation during software development and the usage of CASE tools, that sped up the development team work. Because of this and considering the Berg affirmations [Berg 2001], we believe that the SIGS-S will be a success case, after its deployment, regarding support the management of the Brazilian public health.

Some suggestions for further work are: the deployment of the applications in the context of health care of SUS-MS; the applications maintenance to meet new client needs; increase the applications to treat other usage scenarios in order to deal with more recurrent situations of health care work; conduct experiments to assess effectiveness of the developed applications; the development of a mobile application to support SIGS-S Web Social.

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